Thesis Proposal:

Mapping the native and invasive haplotypes of *Phragmites australis* in the nature preserves of the Little Traverse Conservancy

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Purpose of study

The biodiversity of the state of Michigan, already fragmented and reduced in the wake of widespread logging and development (Penskar et al, 2001), is now threatened by non-native plant invasion (Goldberg, 2007), specifically that of the M Eurasian haplotype of *Phragmites australis*. This study uses GPS and GIS technologies, in conjunction with expertise gained through prior work with the Phragmites Diagnostic Service at Cornell University, to identify and map native and invasive *Phragmites australis* stands in and around the nature preserves of Little Traverse Conservancy (LTC) which are located in Northern Michigan's Emmet, Charlevoix Cheboygan, Chippewa, and Mackinaw counties. The maps produced from this effort will be used by the LTC to guide native biodiversity preservation and restoration efforts to improve and maintain the quality of these Michigan natural areas.

Rationale of study

Reductions in biodiversity have multiple deleterious effects in many areas, including damages to the economy and recreation, a lessening of human health, threats to human rights, and assaults on the intrinsic or spiritual value of nature (National Geographic Society, 2006). Awareness of these impacts can motivate individuals toward efforts to preserve biodiversity. For example, some would argue that maintaining biodiversity is essential for the development of new medications, foods, and other products with potential economic impacts; others would contend that the importance of preservation lies in the recreational opportunities that biodiversity of the environment can provide; still others would fight to preserve biodiversity to allow for the continuation of traditional lifestyles among indigenous peoples and of the vital processes of exchange among the flora and fauna themselves. Though their reasons for doing so vary, most people agree that it is important to try to prevent species extinction. According to recent public opinion polls, "… more than 60% of Americans describe themselves as active environmentalists or sympathetic to the environment…Americans overwhelmingly support our nation's major environmental laws and more than 80% of Americans favor strengthening these environmental standards." (US Mission, 2006). Such statistics suggest that the American people are behind efforts to restore and preserve native biodiversity, thereby improving the natural quality of their environments.

Also important to improving the natural quality of Michigan environments, over 12,000 km of which are Great Lakes coastlines (Smith et al, 1991; Keough et al, 1999), is the maintenance of the Great Lakes coastal wetlands, which have escaped being drained for agriculture or other development (Dahl, 2000) only to be faced with threats from climate change, eutrophication in response to nutrient inflows increased by human activities, and the invasion of exotic plant species or genotypes (Goldberg, 2007). These wetlands not only play an ecological role in Great Lakes ecosystems by providing habitat and food for a variety of native plant and animal species, but they also play economic roles by protecting waterways for recreation and navigation and by serving to filter potential Great Lakes pollutants, including excess nutrients, from the waters which flow through them into those lakes (Mitsch and Gosselink, 2000; Zedler and Kercher, 2004; McClain et al, 2003; Krieger 2003; Mitsch and Wang, 2000). The degree of water quality degradation, particularly in terms of excess inputs of nutrients, has been shown to cause substantial changes in the richness, composition, and density of aquatic plant species in and around lakes (Lougheed et al, 2001; Toivonen and Huttunen, 1995; Bini et al, 1999: Magee et al, 1999). Further, studies have shown that where wetlands receive runoff from urban or agricultural landscapes, invasive plants including *Phragmites australis* (common reed) *Typha spp*. (cattails), and *Phalaris arundinacea* (reed canary grass), often displace the native vegetation (Woo and Zedler, 2002; Boutt et al, 2001; Wayland et al, 2002; Wayland et al, 2003; Duckles et al, in review).

The invasiveness of plant species depends both on plant traits and habitat modifications (Mooney et al, 1986; Galatowisch et al, 1999; Mack et al, 2000). Richardson et al (2000) defines invasive plants as those which "produce reproductive offspring, often in very large numbers, at considerable distances form parent plants (approximate scales: >100 m, <50 years for taxa spreading by seeds and other propagules; >6m / 3 years for taxa spreading by roots, rhizomes, stolons, or creeping stems), and thus have the potential to spread over considerable area" (p. 98). In Michigan coastal wetland systems, prominently problematic emergent graminoids include the M

Eurasian haplotype of *Phragmites australis* (common reed) (Galatowitsch et al, 1999; Zedler and Kercher, 2004).

The M Eurasian haplotype of *Phragmites australis* has the key traits of large biomass, rapid growth, prodigious litter production, extensive clonality, early propagule establishment, and high culm density within stands (Galatowisch et al, 1999; Grace and Harrison, 1986; Mal and Narine, 2004; Zedler and Kercher, 2004; Herrick and Wolf, 2005; Salstonstall, 2002; Rook, 2004; Driscoll, 1999; Howard et al, 2007; Wilcox et al. 2003; Meadows and Saltonstall 2007). Additionally, the invader responds quickly to habitat nutrient additions which allows it to increase its primary productivity over that of coexisting species thereby facilitating its dominance in nutrient enriched wetland communities. (Tilman and Wedin, 1991; Miao and Sklar, 1998; Keddy, 1990; Woo and Zedler, 2002; Green and Galatawisch, 2001; Lavergne and Molofsky, 2004; Zedler and Kercher 2004, Schooler et al, 2006; Boers et al, 2007). These characteristics, especially in concert, typically inhibit the growth of other plan species and result in a shift from native plant biodiversity to a non-native vegetative monoculture. Further, the formation of such invasive monocultures can significantly alter local hydrology and nutrient cycling processes, and cause soil modifications at the invasion sites as a result of the increased retention that their rapid substantial biomasses accumulation requires (Wang et al., 2006; Wilcox et al. 2003; Kercher and Zedler, 2004; Ehrenfeld, 2003; Goldberg, 1990; Hobbie, 1992; Wilson and Agnew, 1992; Lavorel & Garnier, 2002; Eviner & Chapin, 2003). Such plant-mediated environmental changes have been proposed to be responsible for generating positive feedbacks which allow invading plant species to increase their own populations as they shift the environment towards better meeting their needs over those of their competitor species (Goldberg, 2007). However, it has also been proposed that negative feedbacks, which cause the invader populations to decrease, are also generated as these same environmental changes accumulate such that the environment becomes substantially different than what was favorable for the initial invasion (Debra Goldberg, personal communication). If the latter hypothesis is correct, the environmental changes induced by one plant invasion may facilitate further invasions by other species, which could further reduce native biodiversity.

Phragmites australis is a perennial grass with circumboreal distribution (Chadde, 2002) and the ability to grows successfully in a variety of habitats including along brackish and freshwater shorelines, along streams and creeks, in fens, bogs, marshes, swamps, springs, and ponds, in agricultural fields, in roadside ditches, and in drier upland areas (Blossey, 2002). Eleven of its 27 known haplotypes, together forming the subspecies *americanus*, are native components of mixed wetland communities in the United States (Saltonstall, 2002; Lambert and Casagrande, 2006; DEQ, 2007). In the late nineteenth century, a Eurasian strain (haplotype M, *P. australis* subsp. *australis*), likely introduced in ship ballast waters dumped at port, entered the eastern U.S. and began aggressively spreading such that it has now formed dense monocultures along the east coast which have replaced *P. australis americanus* and other native plants, diminishing habitat quality and overall biodiversity (Meadows and Saltonstall, 2007; Saltonstall and Stevenson, 2007; Saltonstall, 2002). By the 1960s, the invasive haplotype had established in southern Michigan, and recent studies of *Phragmites* populations along the Lake Erie coastline estimate the ratio of invasive to native *Phragmites* there currently at 9:1 (Wilcox et al. 2003).

Land managers in northern Michigan have noticed increases in *Phragmites* abundance in recent years (Cindy Mom, personal communication). Northern Michigan may therefore be headed toward native species replacement similar to that observed downstate making this a potentially critical time for addressing invasive *Phragmites* management programs. Thus far, efforts to protect northern Michigan wetlands against invasive *Phragmites* have produced management techniques which include cutting, burning, and herbicide treatments (DEQ, 2007; Blossey, 2002). However, due to lack of awareness of the morphological distinctions between invasive and native *Phragmites*, these efforts may be eradicating the native reed by being applied indiscriminately (Lambert and Casagrande, 2006). This possibility necessitates typing known *Phragmites* stands as either native or invasive prior to enacting management plans. Currently, morphological differences between the native and M Eurasian haplotypes are being compiled by Bernd Blossey, director of the Ecology and Management of Invasive Plants Program at Cornell University (Blossey, 2002). Using the program's collection of observed differences between native and introduced *Phragmites*, one can learn to differentiate between the two subspecies. The program's Phragmites Diagnostic Service can also be utilized for differentiation, though it should be used for confirming the accuracy of one's use of the morphological differences for typing *Phragmites* stands rather than be relied upon for all typing needs. Using these resources from Cornell, Phragmites stands can be typed locally.

Combining such field identification with GPS and GIS technology, has the potential to be even more useful. The addition of a mapping component to the process of distinguishing between native and invasive *Phragmites* stands would allow wetlands land managers access to information valuable in monitoring local *Phragmites* populations and controlling invading stands while preserving native ones. The Little Traverse Conservancy, a coalition dedicated to preserving the natural diversity and beauty of Northern Michigan by acquiring and protecting significant land and scenic areas (Little Traverse Conservancy, nd), is interested in obtaining maps indicating the locations of native and invasive *Phragmites australis* stands in and around their nature preserves, which are spread throughout Northern Michigan's Emmet, Charlevoix Cheboygan, Chippewa, and Mackinaw counties.

Hypothesis

The production of maps which distinguish between the native and invasive haplotypes of *Phragmites australis* in and around the nature preserves of the Little Traverse Conservancy can provide a guide for native biodiversity preservation and restoration efforts to improve and maintain the natural quality of natural areas in Northern Michigan.

Methods

Background study – completed summer 2007

Stand Identification

Phragmites stands in areas previously noted by LTC personnel as well as by students and faculty at the University of Michigan Biological station located in northern

Michigan's Cheboygan county, were visited. Recordings were made of the stand locations – site name (if applicable), site description (including habitat type: brackish tidal, freshwater tidal, floating mat, marsh, swamp, fen, spring, bog, pond, lakeshore, upland, along stream/creek, roadside ditch, agricultural field, or other), and site longitude and latitude (using GPS). For example:

Site name – Maple Point
Site description – NW corner of Maple Bay in the SW corner of Douglas Lake, Cheboygan County, Michigan; lakeshore habitat with periodically flooded growing conditions.
Longitude – 84°43'27.9"
Latitude – 45°34'37.2"

Additionally, measures of stand success were made at each site including: length of stand (the longest straight line through the stand), width of stand (the widest line perpendicular to the length measurement, stand culm density (number of culms / m^2 in the densest section of the stand, with ranges as follows: sparse = < 20 culms / m^2; medium = 21-40 culms / m^2; and dense = > 40 culms / m^2), culm height (height of the tallest culm in the 1 m^2 quadrat in which the culm density was measured), culm diameter (measured at the litter level on the tallest culm in the quadrat). For example, at Maple Point these values were:

Stand size: 10 m long x 5 m wide
Culm density: 8 culms / m^2 (sparse)
Culm height: 1.5 m
Culm diameter: 1.8 cm

Next, stands were typed as either native or invasive based on careful comparison of their morphological characteristics to those listed on Cornell's Ecology and Management of Invasive Plants Program website. For example, the stand at Maple Point was typed as native. Finally, a field collection was made from each site for confirmation of typing accuracy through the Cornell University Phragmites Diagnostic Service. This collection was made following the instructions from Bernd Blossey attached in the Appendix.

Stand Mapping

A GPS waypoint was recorded at the densest part (the m^2 quadrat location) of each Phragmites stand identified as native using the eTrex® Vista Cx portable GPS receiver manufactured by Garmin. GPS waypoints were recorded at the eight cardinal and ordinal points around the perimeter of each Phragmites stand identified as invasive as well as at the quadrat location. The GPS waypoints were downloaded into the software program GPS Utility, with which shape files were created. The shape files from GPS Utility were then exported into ArcMap 9.1 where they were overlaid onto shape files indicating the locations of the following features in northern lower Michigan's Cheboygan, Emmet, and Mackinaw Counties: streams, rivers, wetlands, lakes, LTC nature preserves, county boundaries, cities, and major roads.

Results of background study –

Stand Identification

Field collections from nine stands were sent to Cornell; Bernd Blossey's identification of each was consistent with this researcher's field identifications, confirming acquisition of the ability to use morphological differences for typing *Phragmites* stands. Stand location and success data was also compiled (see Table1).

Stand Mapping

Cheboygan County:

One native stand was found on the NE shoreline of Douglas Lake (see Fig 1); two native and one invasive stand were identified in Cheboygan State Park (See Fig 1); and a mixed stand was discovered in Cheboygan Marsh (See Fig 2a and Fib 2b).

Emmet County:

Five native and two invasive stands were identified at Sturgeon Bay (see Fig 3, Fig 4a, and Fig 4b); eight native stands were found along Oden Island Road (see Fig 5); one invasive stand was found along US-31 on the W side of Crooked Lake (see Fig 6); one invasive stand was found along US-31 about 2 miles S of Pellston (see Fig 7); ten native stands were found in Lark's Lake (see Fig 8); and one native stand was identified along Robinson Road south of Lark's Lake (see Fig 8).

Mackinaw County:

Eight native stands were identified in Duck Bay (see Fig 9).

Proposed study –

Stand Identification

This study proposes to evaluate LTC nature preserves and the areas surrounding them, particularly major roadways, for the presence or absence of *Phragmites australis* stands and to type all located stands during the summer of 2008 using the methods and materials described in the background study.

Stand Mapping

This study further proposes to record GPS waypoints denoting the presence of either native or invasive *Phragmites* or the absence of *Phragmites* altogether in and around the LTC preserves and to produce GIS maps for the LTC from this data. Again, this will be done using the methods and resources described in the background study.

Potential Project Benefits

The described application of GPS and GIS technologies to *Phragmites* stand locations in and around LTC nature preserves, following their morphology based typing as either native or of the invasive M Eurasian haplotype, will generate maps which can be used to guide native biodiversity preservation and restoration efforts to improve and maintain the quality of these Michigan natural areas. Importantly, such maps can help prevent the destruction of native *Phragmites* stands in efforts to eradicate its invasive counterpart. Additionally, the more detailed maps generated for invasive stands as a result of marking waypoints at their cardinal and ordinal points, coupled with the stand success data collected at each invasive stand location, can be used to monitor the growth and spread of those invasive stands to further guide native biodiversity preservation and restoration efforts.

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Figure Legend

Fig 1: GIS map of sampling sites in Cheboygan County
Both Cheboygan State Park and Cheboygan Marsh sampling sites are located within the Cheboygan city limits; the marsh stand is located furthest west of the four stands within Cheboygan.

Fig 2: GIS map of Cheboygan Marsh mixed Phragmites stand
Fig 2b is a a closer view of Fig 2a.

Fig 3: GIS map of Emmet County's Sturgeon Bay sampling sites

Fig 4: GIS map of Sturgeon Bay's invasive Phragmites stands
Fig 4b is a a closer view of Fig 4a.

Fig 5: GIS map of native Phragmites stands along Emmet County's Oden Island Road, which runs on a bridge across Crooked Lake to Oden Island

Fig 6: GIS map of invasive Phragmites stand along US-31 on the west side of Crooked Lake in Emmet County

Fig 7: GIS map of invasive Phragmites stand along US-31 about 2 miles S of Pellston in Emmet County
Fig 7b is a a closer view of Fig 7a

Fig 8: GIS map of native Phragmites stands in Lark's Lake and nearby Robinson Road in Emmet County

Fig 9: GIS map of native Phragmites stands in Duck Bay in Mackinaw County

Fig 9b is a a closer view of Fig 9a.

Figures

Fig 1

2007 Cheboygan County Phragmites (Pa) Map - Preliminary

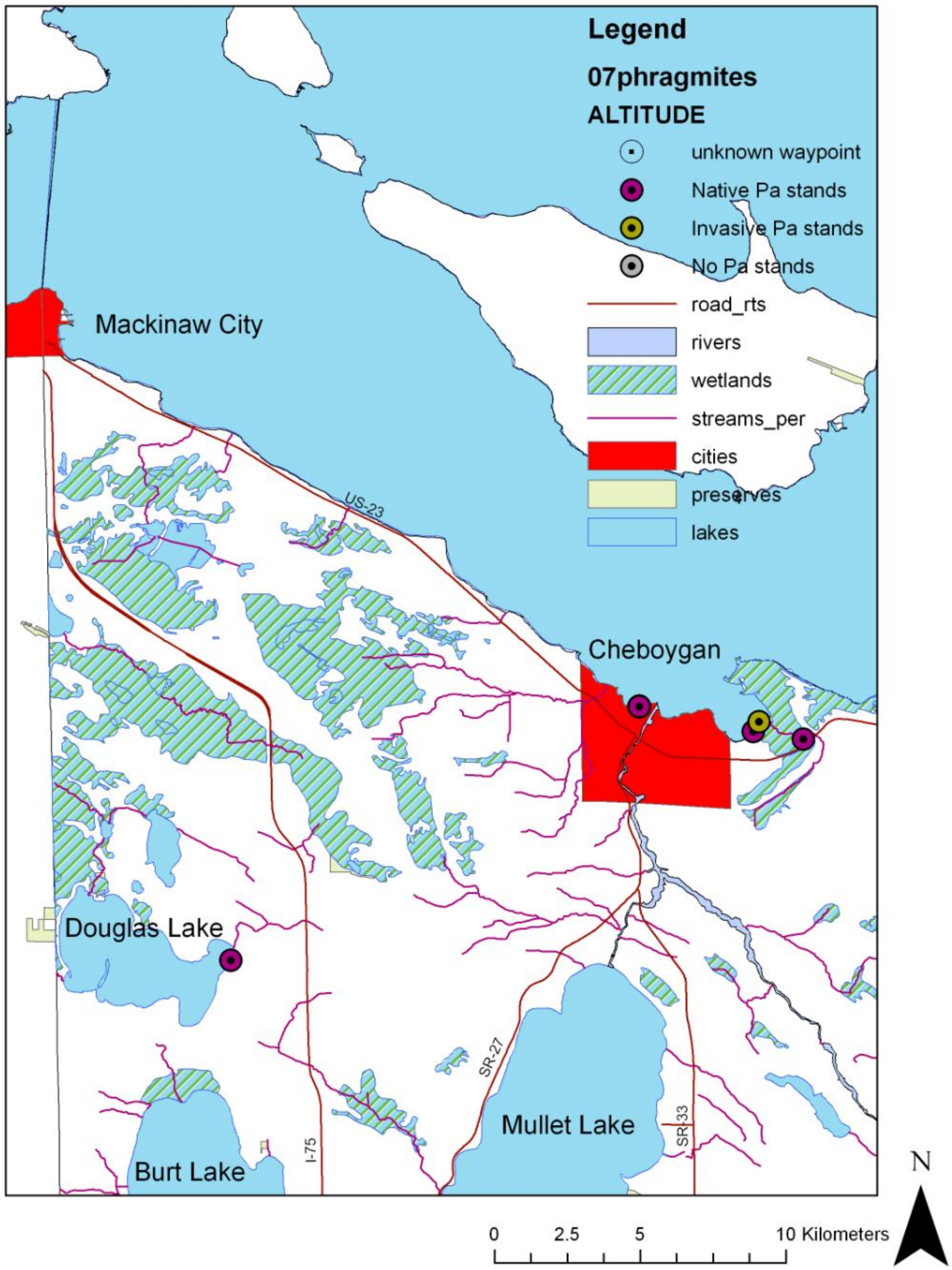
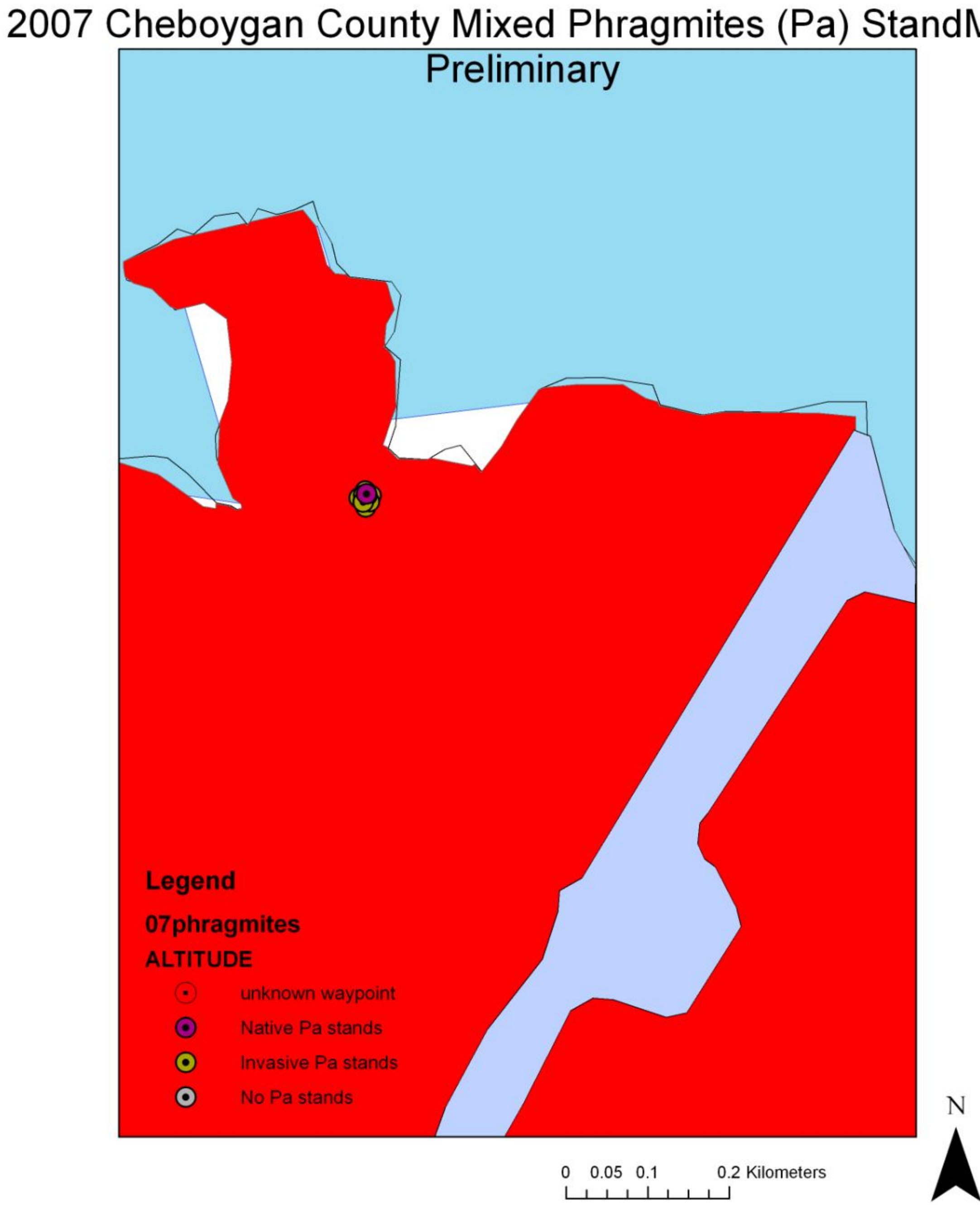


Fig 2a



2007 Cheboygan County Mixed Phragmites (Pa) StandMap
Preliminary
Legend
07phragmites
ALTITUDE
unknown waypoint
Native Pa stands
Invasive Pa stands
No Pa stands
0 0.05 0.1 0.2 Kilometers
N

Fig 2b

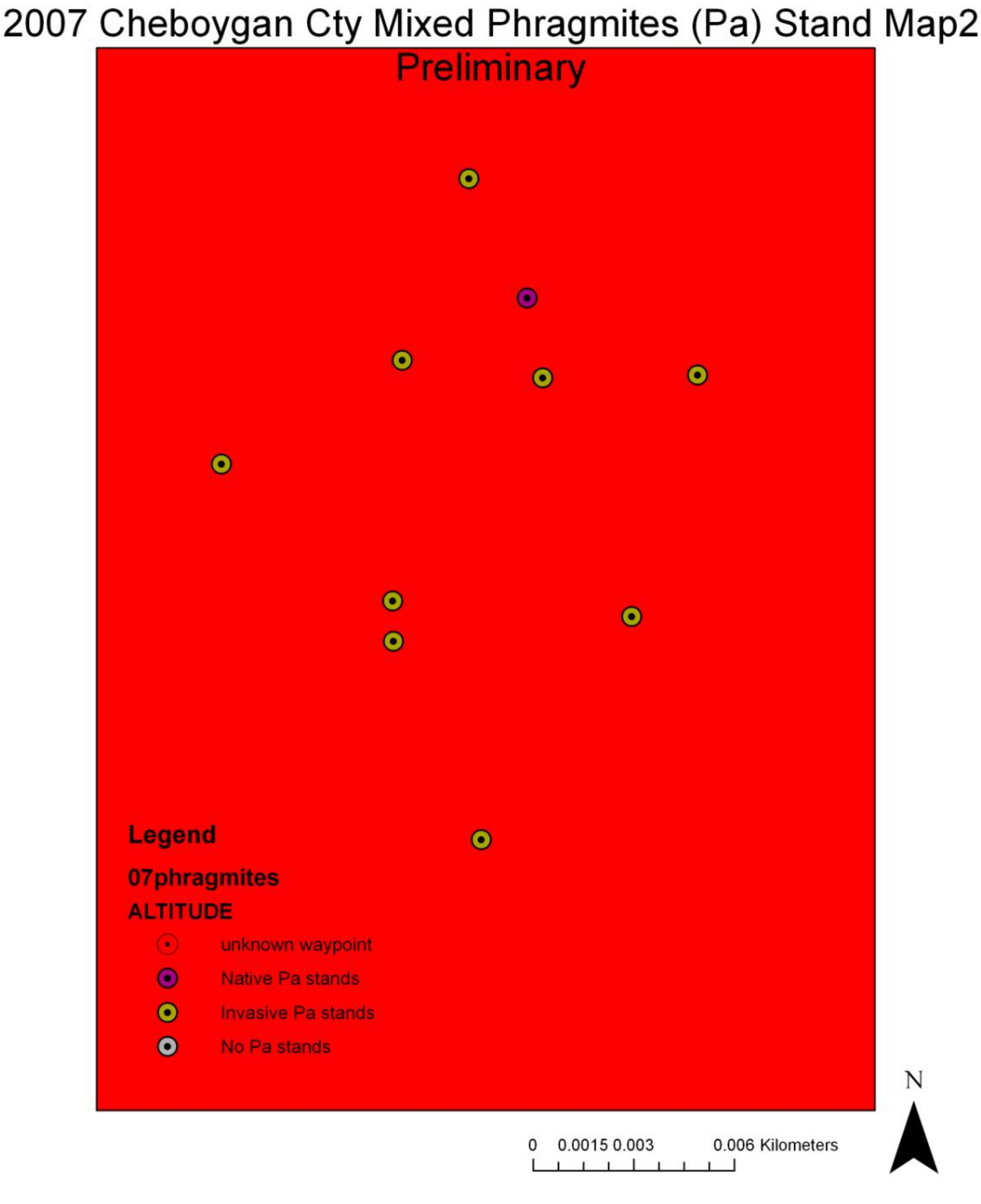

2007 Cheboygan Cty Mixed Phragmites (Pa) Stand Map2
Preliminary
Legend
07phragmites
ALTITUDE
unknown waypoint
Native Pa stands
Invasive Pa stands
No Pa stands
N
0 0.0015 0.003 0.006 Kilometers

Fig 3

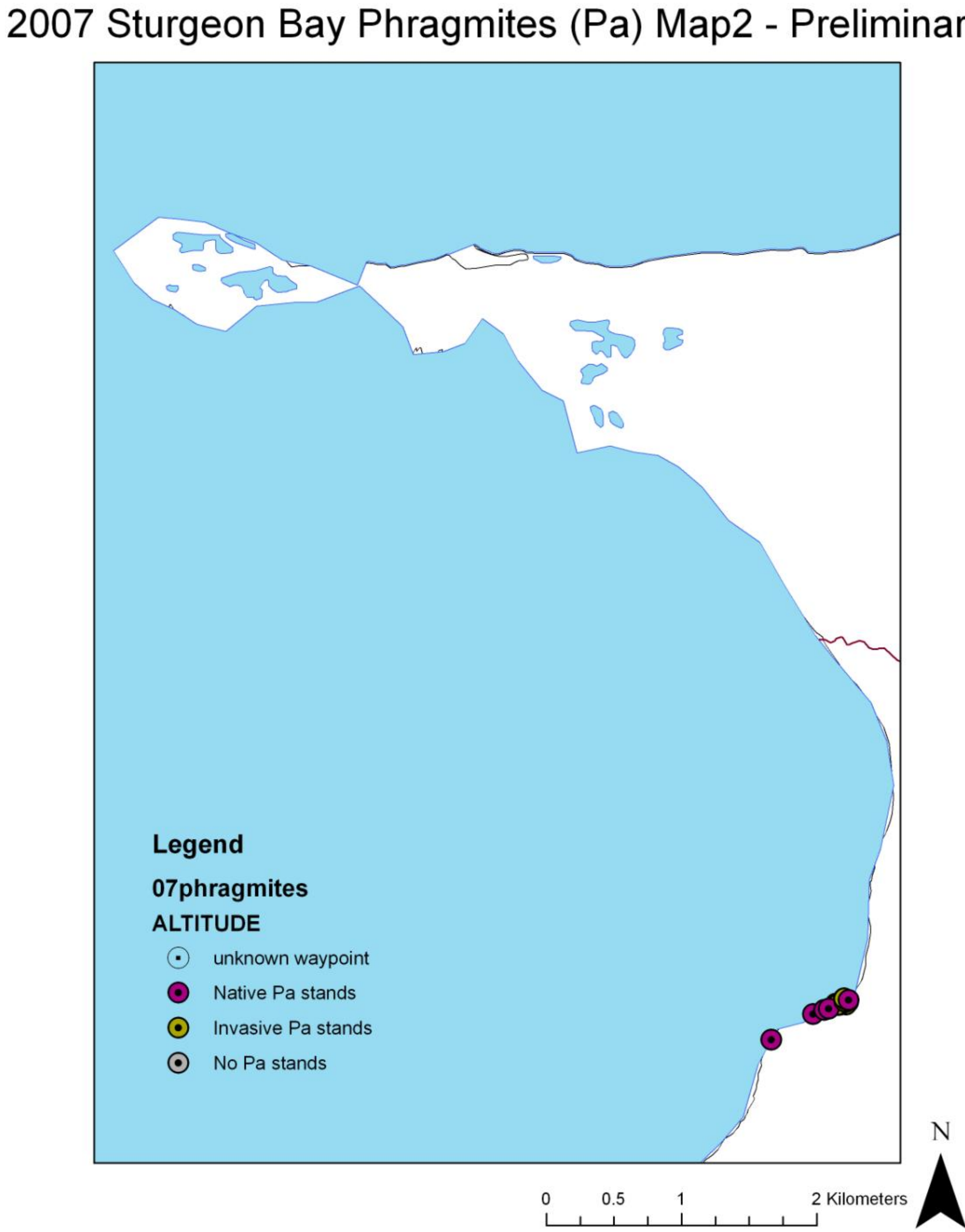

2007 Sturgeon Bay Phragmites (Pa) Map2 - Preliminary
Legend
07phragmites
ALTITUDE
unknown waypoint
Native Pa stands
Invasive Pa stands
No Pa stands
N
0
0.5
1
2 Kilometers

Fig 4a

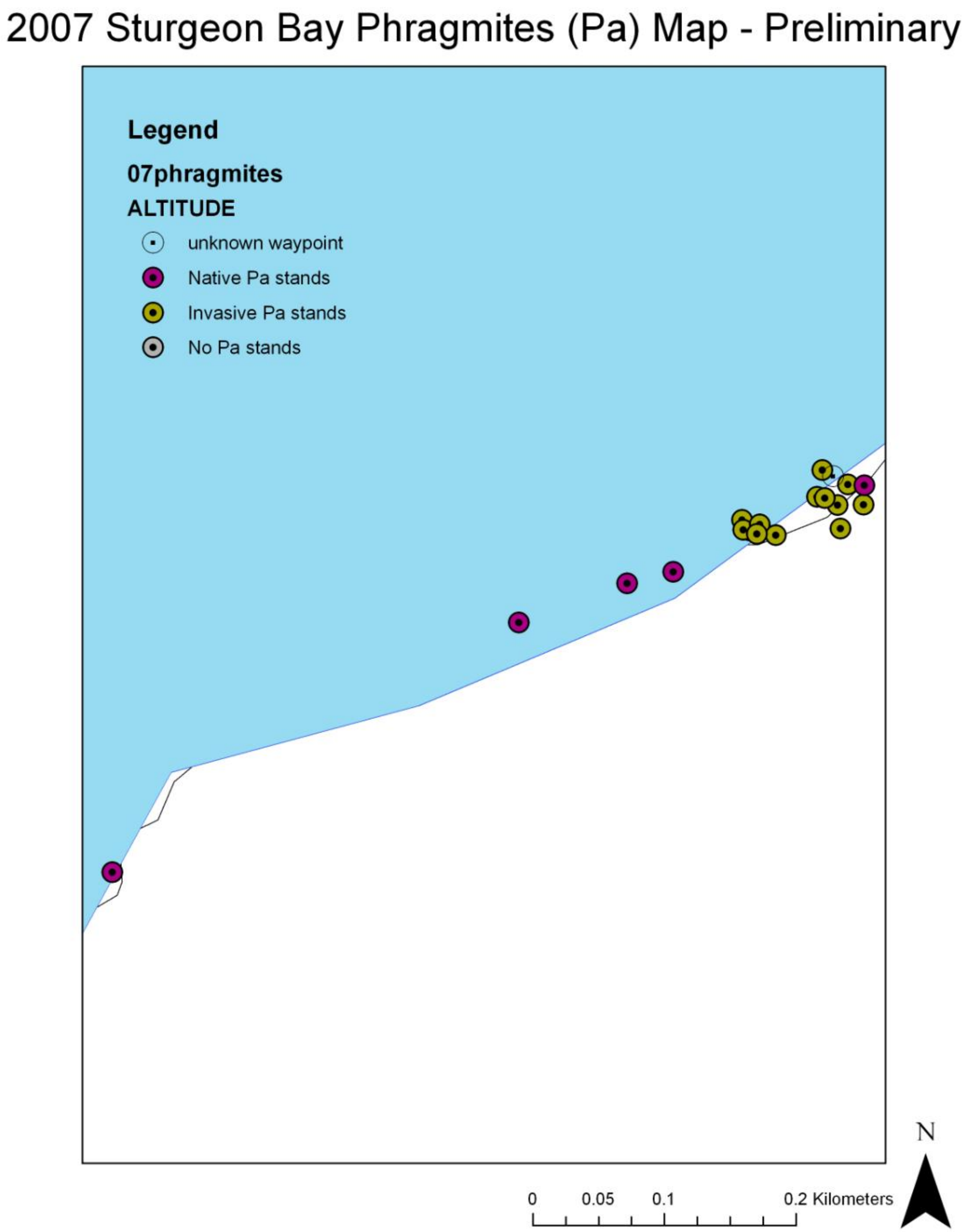

2007 Sturgeon Bay Phragmites (Pa) Map - Preliminary
Legend
07phragmites
ALTITUDE
unknown waypoint
Native Pa stands
Invasive Pa stands
No Pa stands
N
0
0.05
0.1
0.2 Kilometers

Fig 4b

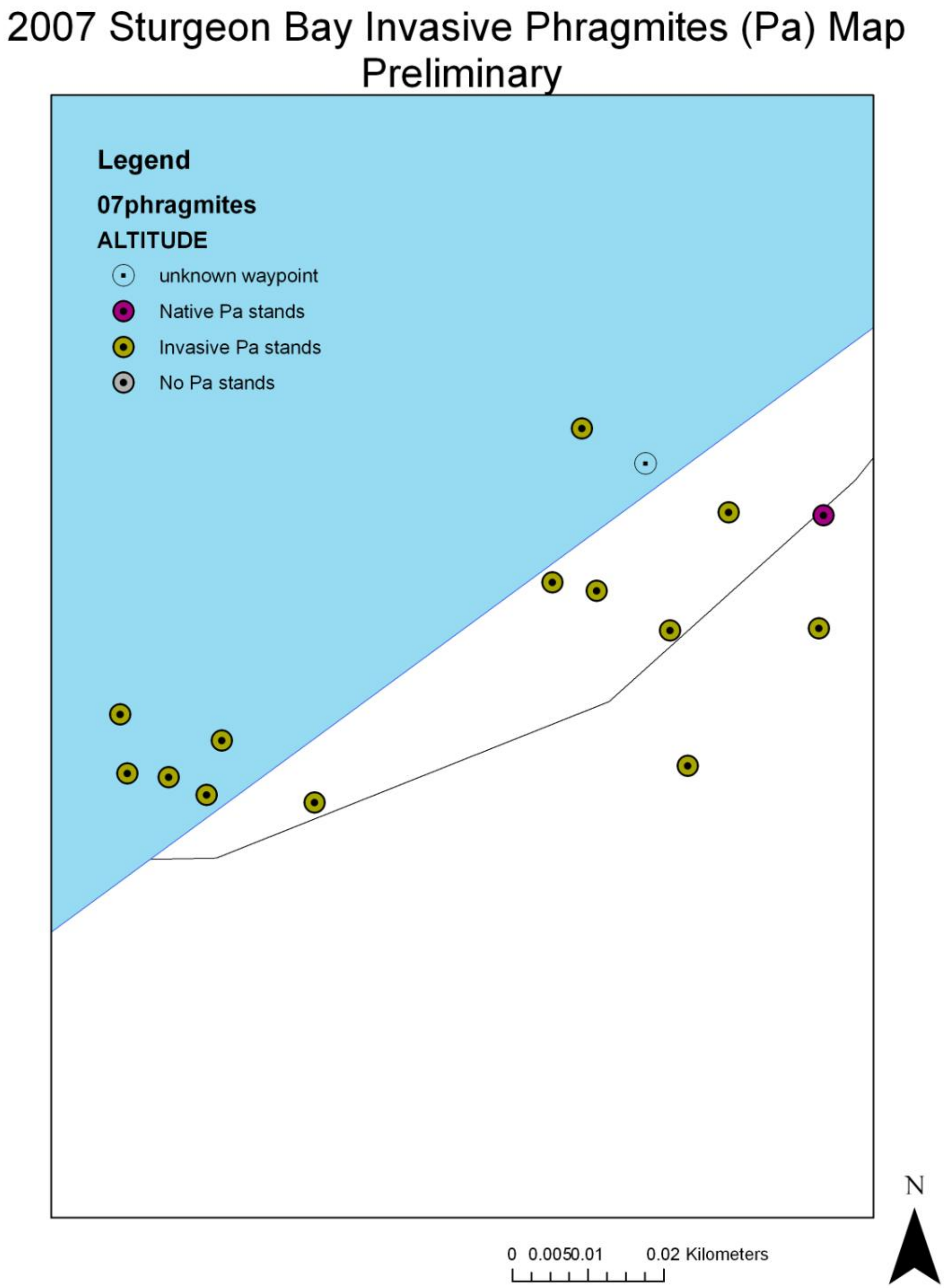

2007 Sturgeon Bay Invasive Phragmites (Pa) Map
Preliminary
Legend
07phragmites
ALTITUDE
unknown waypoint
Native Pa stands
Invasive Pa stands
No Pa stands
N
0 0.0050.01 0.02 Kilometers

Fig 5

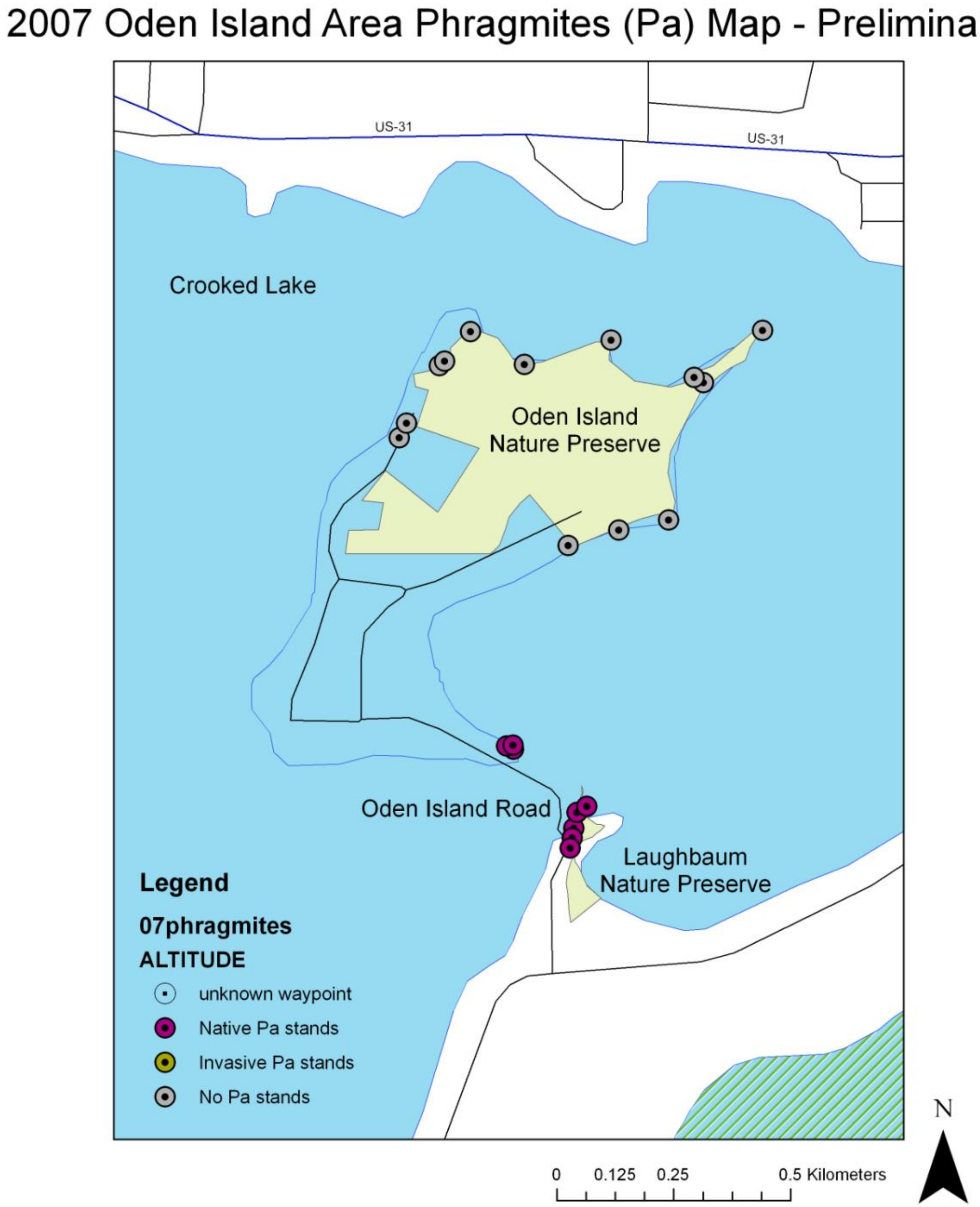

2007 Oden Island Area Phragmites (Pa) Map - Preliminary
US-31
US-31
Crooked Lake
Oden Island
Nature Preserve
Oden Island Road
Laughbaum
Nature Preserve
Legend
07phragmites
ALTITUDE
unknown waypoint
Native Pa stands
Invasive Pa stands
No Pa stands
N
0
0.125
0.25
0.5 Kilometers

Fig 6

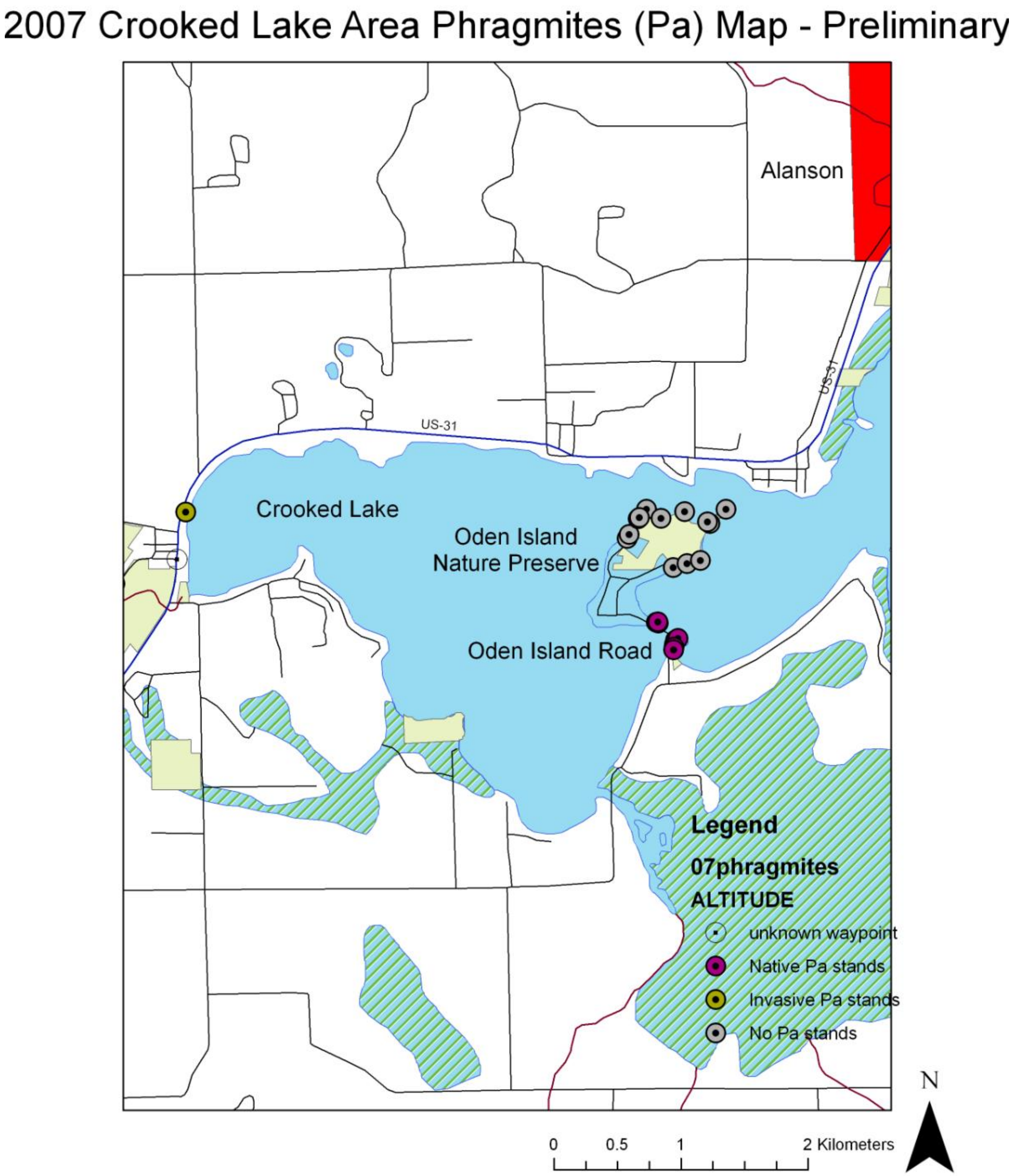

2007 Crooked Lake Area Phragmites (Pa) Map - Preliminary
Alanson
US-31
US-31
Crooked Lake
Oden Island
Nature Preserve
Oden Island Road
Legend
07phragmites
ALTITUDE
unknown waypoint
Native Pa stands
Invasive Pa stands
No Pa stands
N
0
0.5
1
2 Kilometers

Fig 7a

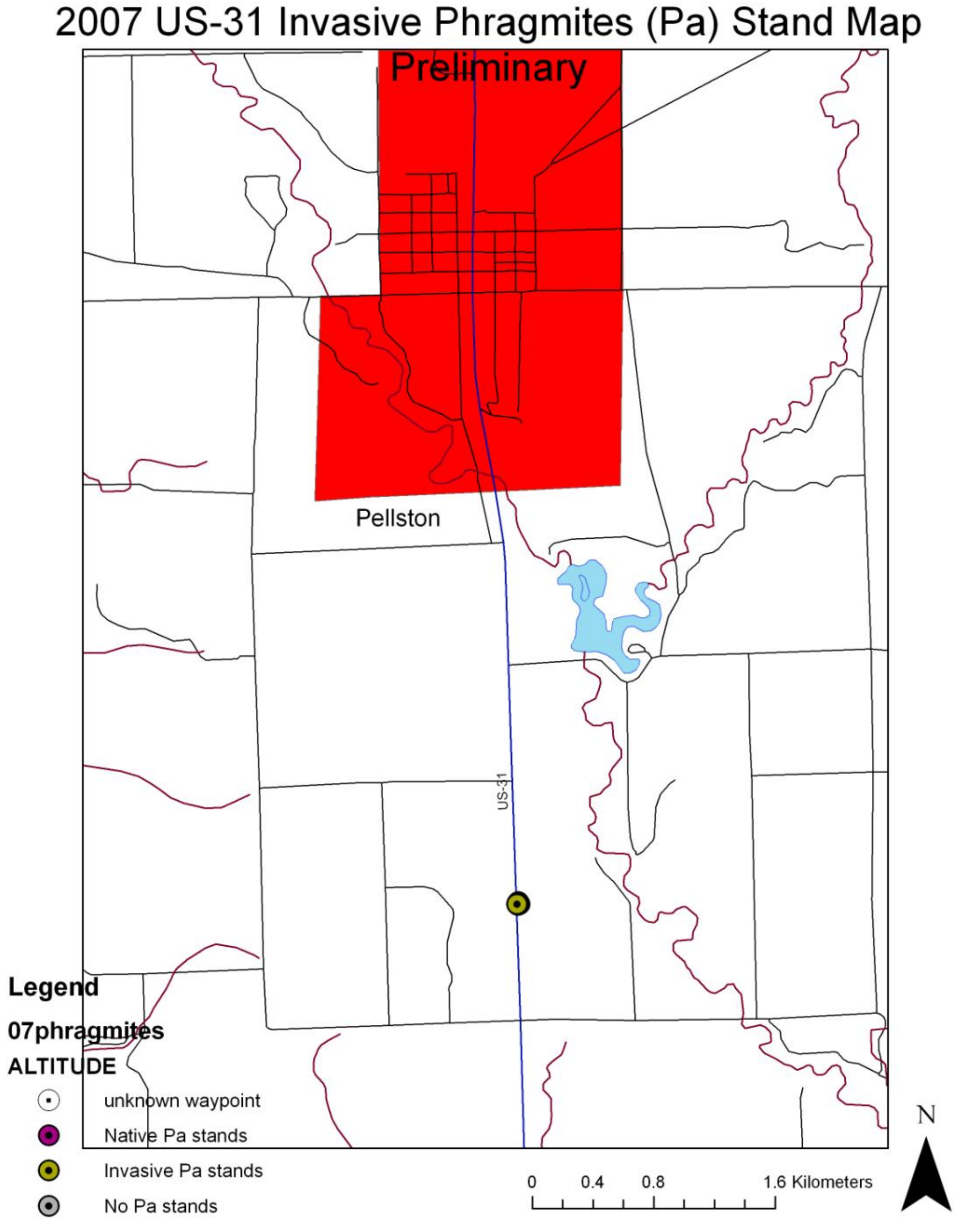

2007 US-31 Invasive Phragmites (Pa) Stand Map
Preliminary
Pellston
US-31
Legend
07phragmites
ALTITUDE
unknown waypoint
Native Pa stands
Invasive Pa stands
No Pa stands
0
0.4
0.8
1.6 Kilometers
N

Fig 7b

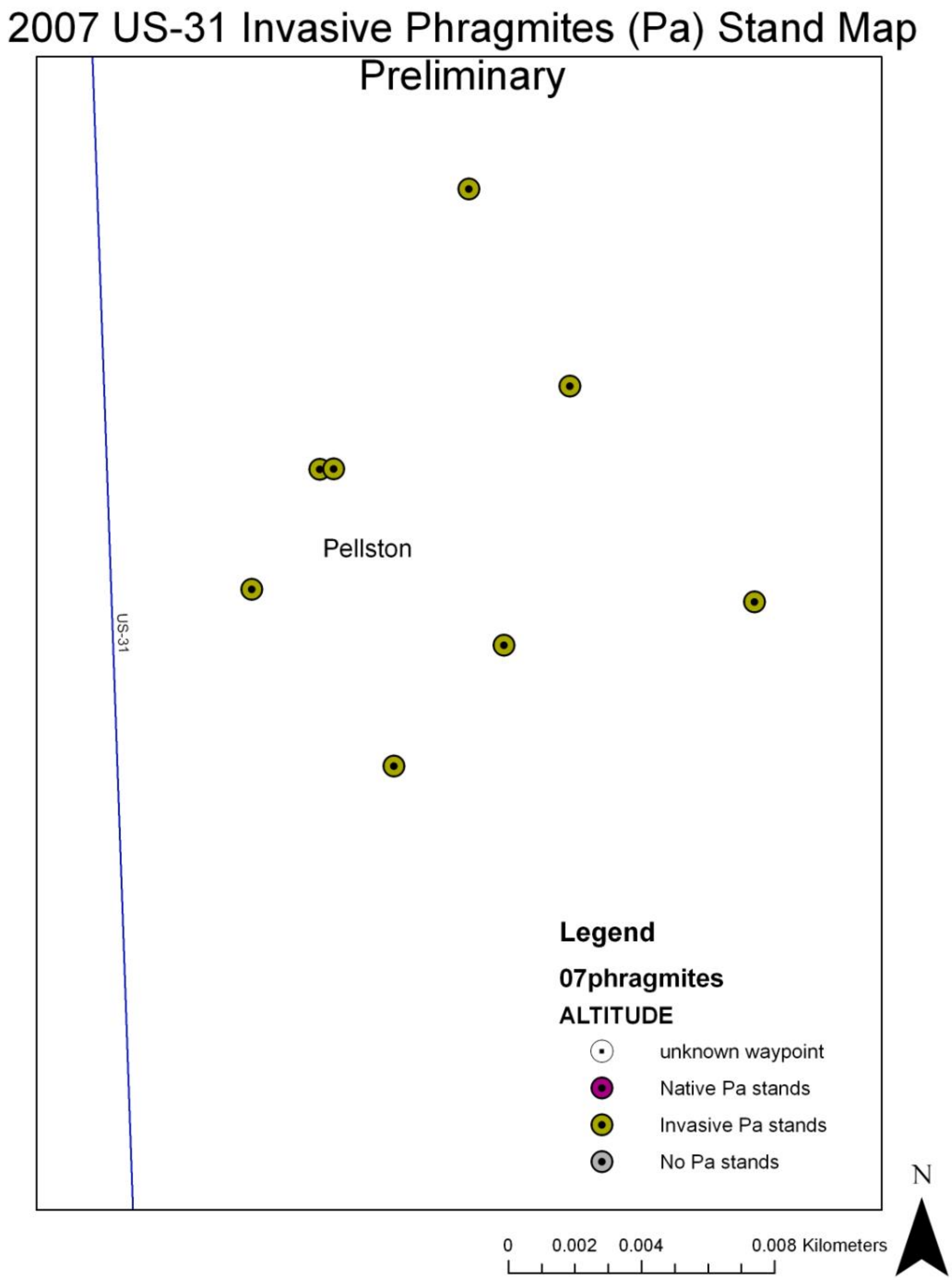
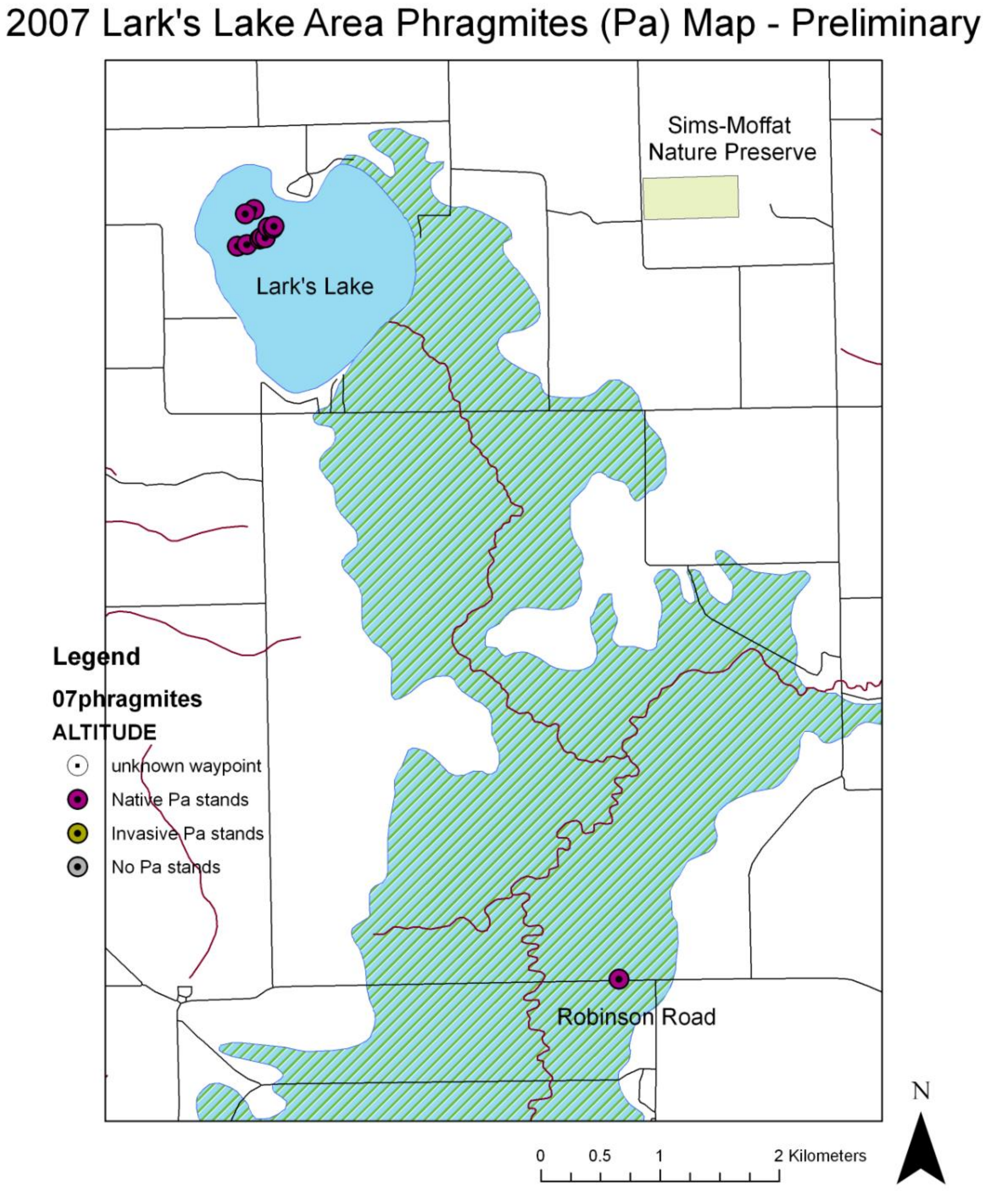

2007 US-31 Invasive Phragmites (Pa) Stand Map
Preliminary
Pellston
US-31
Legend
07phragmites
ALTITUDE
unknown waypoint
Native Pa stands
Invasive Pa stands
No Pa stands
N
0
0.002
0.004
0.008 Kilometers

Fig 8



2007 Lark's Lake Area Phragmites (Pa) Map - Preliminary
Sims-Moffat
Nature Preserve
Lark's Lake
Legend
07phragmites
ALTITUDE
unknown waypoint
Native Pa stands
Invasive Pa stands
No Pa stands
Robinson Road
N
0
0.5
1
2 Kilometers

Fig 9a

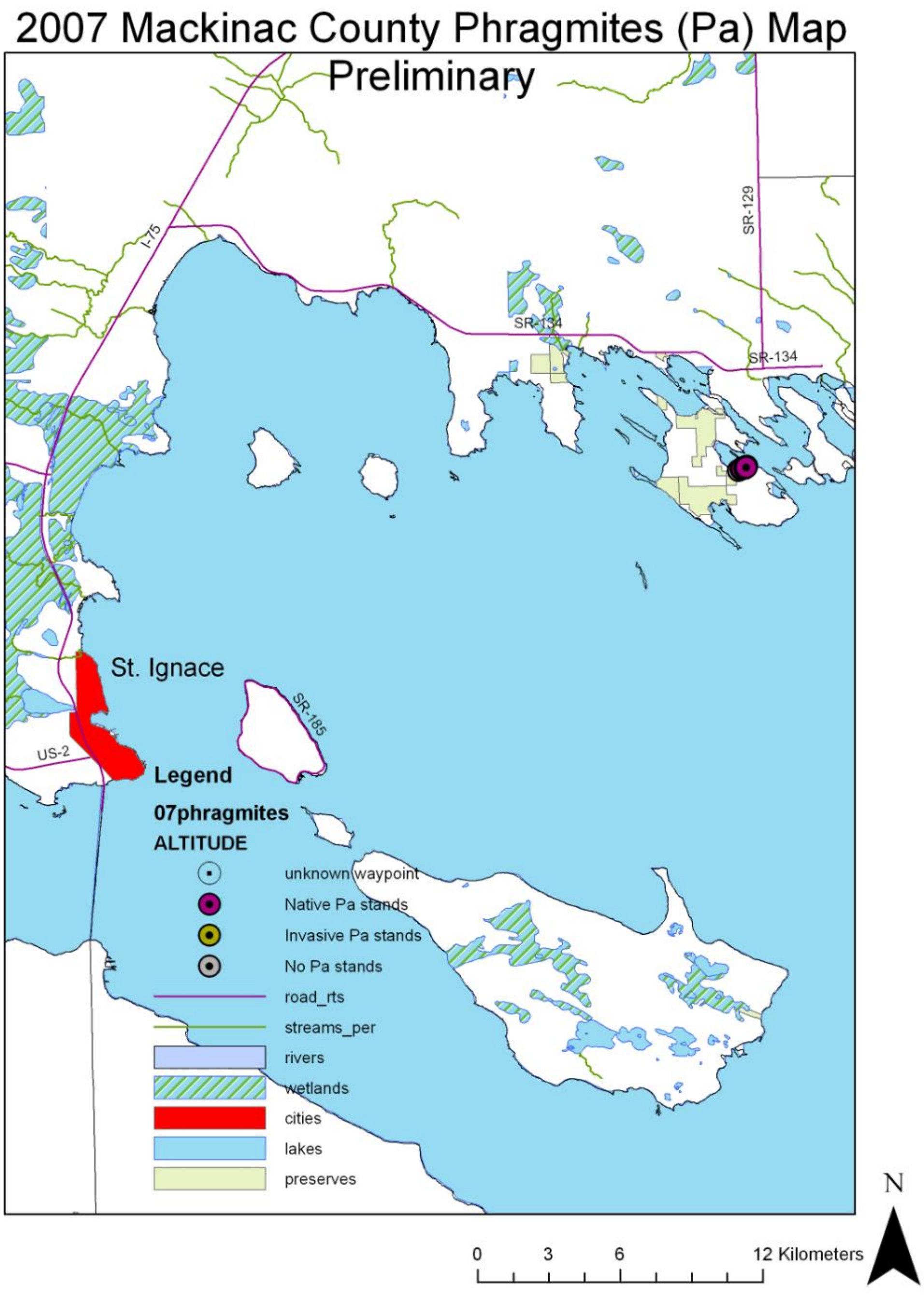
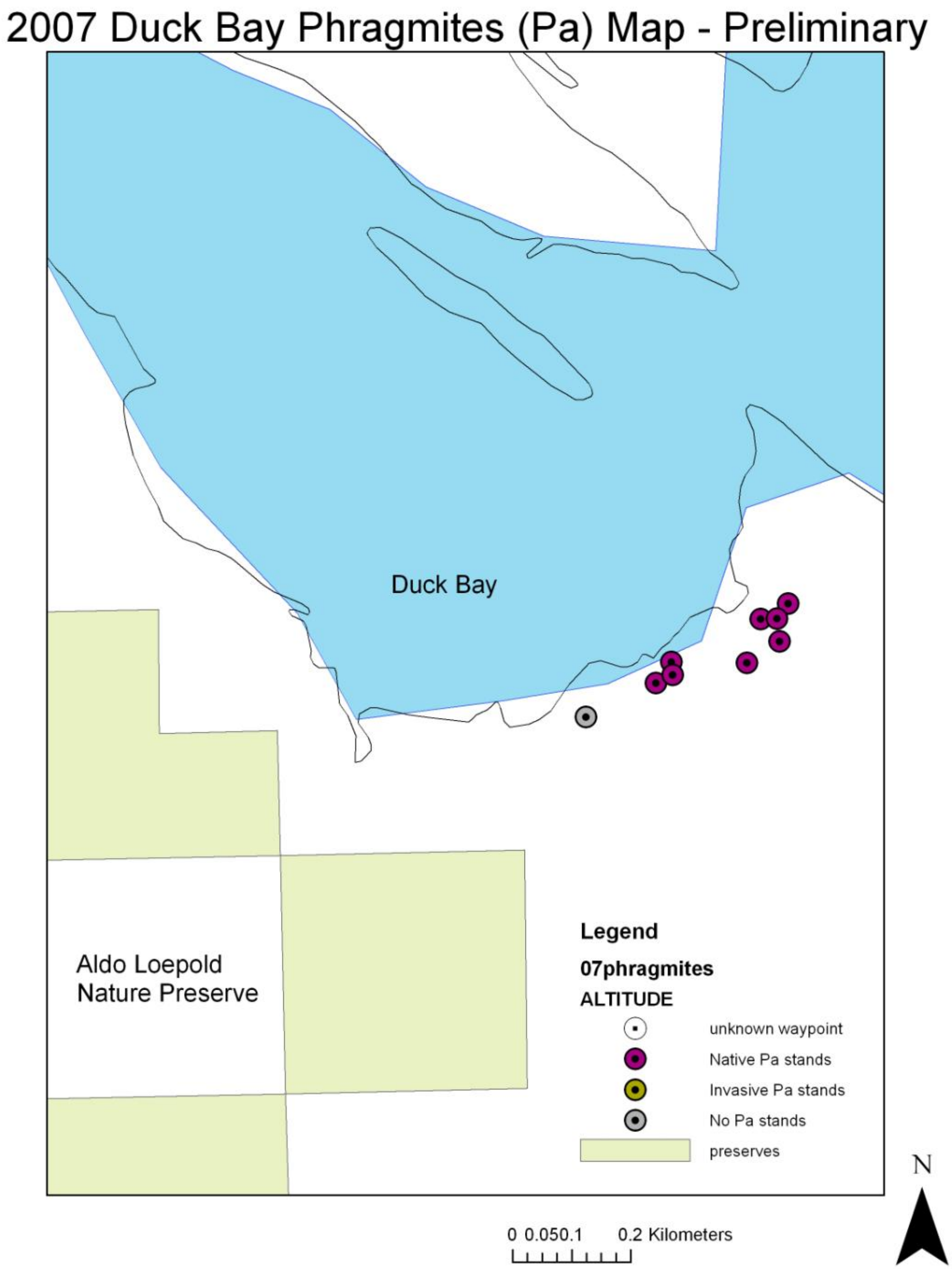

2007 Mackinac County Phragmites (Pa) Map
Preliminary
I-75
SR-129
SR-134
SR-134
St. Ignace
SR-185
US-2
Legend
07phragmites
ALTITUDE
unknown waypoint
Native Pa stands
Invasive Pa stands
No Pa stands
road_rts
streams_per
rivers
wetlands
cities
lakes
preserves
N
0 3 6 12 Kilometers

Fig 9b



2007 Duck Bay Phragmites (Pa) Map - Preliminary
Duck Bay
Aldo Loepold
Nature Preserve
Legend
07phragmites
ALTITUDE
unknown waypoint
Native Pa stands
Invasive Pa stands
No Pa stands
preserves
N
0 0.050.1 0.2 Kilometers

Table Legend

Table 1: Phragmites stand location and success data

Table 1

Site Name / Description	Sturgeon Bay #1	Sturgeon Bay #2	Sturgeon Bay #3	Sturgeon Bay #4	Sturgeon Bay #5	Sturgeon Bay #6	Sturgeon Bay #7
Site county	Emmet	Emmet	Emmet	Emmet	Emmet	Emmet	Emmet
habitat type	lakeshore	lakeshore	lakeshore	lakeshore	lakeshore	lakeshore	lakeshore
quadrat waypoint	67	68	69	70	81	82	86
longitude							
latitude							
stand length	3 m	8.2 m	15.5 m	29.1 m	0.5 m	31.9 m	2m
stand width	3 m	2.2 m	9.4 m	23.5 m	0.01 m	19.3 m	1.2 m
culm density	37 / m^2	14 / m^2	9 / m^2	17 / m^2	2 / m^2	43 / m^2	7 / m^2
culm height	124 cm	114 cm	124 cm	186 cm	not measured	214 cm	130 cm
culm diameter	2.3 cm	1.7 cm	2 cm	2.1 cm	not measured	3.2 cm	1.8 cm
stand type	NATIVE	NATIVE	NATIVE	INVASIVE	NATIVE	INVASIVE	NATIVE

Site Name / Description	Oden Island Road #1	Oden Island Road #2	Oden Island Road #3	Oden Island Road #4	Oden Island Road #5	Oden Island Road #6	Oden Island Road #7
Site county	Emmet	Emmet	Emmet	Emmet	Emmet	Emmet	Emmet
habitat type	roadside and lakeshore	roadside and lakeshore	roadside and lakeshore	roadside and lakeshore	roadside and lakeshore	roadside and lakeshore	roadside and lakeshore
quadrat waypoint	37	38	39	94	95	96	97
longitude							
latitude							
stand length	20 m	4 m	14.5 m	37 m	20 m	13 m	24 m
stand width	4 m	2 m	3.5 m	25 m	11.5 m	5 m	14 m
culm density	36 / m^2	59 / m^2	73 / m^2	107 / m^2	28 / m^2	12 / m^2	52 / m^2
culm height	157.7 cm	180 cm	187 cm	218 cm	246 cm	210 cm	212.5 cm
culm diameter	2 cm	2 cm	1.1 cm	2 cm	2.7 cm	2.1 cm	2.1 cm
stand type	NATIVE	NATIVE	NATIVE	NATIVE	NATIVE	NATIVE	NATIVE

Site Name / Description	Oden Island Road #8	US-31 @ Crooked Lake	US-31 S of Pellston	Lark's Lake #1	Lark's Lake #2	Lark's Lake #3	Lark's Lake #4
Site county	Emmet	Emmet	Emmet	Emmet	Emmet	Emmet	Emmet
habitat type	roadside and lakeshore	roadside ditch	roadside ditch	in lake	in lake	in lake	in lake
quadrat waypoint	98	35	108	171	161	162	163
longitude							
latitude							
stand length	15 m	4 m	13.1 m	11.7 m	15.6 m	7.8 m	9.1 m
stand width	10 m	3 m	11.05 m	7.8 m	15.6 m	6.5 m	9.1 m
culm density	99 / m^2	33 / m^2	76 / m^2	61 / m^2	dense	medium	medium
culm height	242 cm	203 cm	261 cm	214 cm	not measured	not measured	not measured
culm diameter	1.4 cm	1.3 cm	2.9 cm	1.9 cm	not measured	not measured	not measured
stand type	NATIVE	INVASIVE	INVASIVE	NATIVE	NATIVE	NATIVE	NATIVE

Site Name / Description	Lark's Lake #5	Lark's Lake #6	Lark's Lake #7	Lark's Lake #8	Lark's Lake #9	Lark's Lake #10	Robinson Road S of Lark's Lake
Site county	Emmet	Emmet	Emmet	Emmet	Emmet	Emmet	Emmet
habitat type	in lake	in lake	in lake	in lake	in lake	in lake	roadside ditch
quadrat waypoint	164	165	166	167	168	169	173
longitude							
latitude							
stand length	10.4 m	11.7 m	16.9 m	16.9 m	11.7 m	20.8 m	62 m
stand width	7.8 m	9.1 m	15.6 m	11.7 m	9.1 m	11.7 m	8.7 m
culm density	dense	dense	sparse	sparse	dense	medium	70 / m^2
culm height	not measured	not measured	not measured	not measured	not measured	not measured	232 cm
culm diameter	not measured	not measured	not measured	not measured	not measured	not measured	1.4 cm
stand type	NATIVE	NATIVE	NATIVE	NATIVE	NATIVE	NATIVE	NATIVE

Site Name / Description	Douglas Lake	Cheboygan State Park #1	Cheboygan State Park #2	Cheboygan State Park #3	Cheboygan Marsh #1	Cheboygan Marsh #2	Duck Bay
Site county	Cheboygan	Cheboygan	Cheboygan	Cheboygan	Cheboygan	Cheboygan	Mackinaw
habitat type	lakeshore	lakeshore	lakeshore	lakeshore	upland	upland	upland
quadrat waypoint	40	157	160	158	135	136	49 (47-49 and 51-55 could all be one large stand)
longitude							
latitude							
stand length	50 m	17.5 m	not measured	23.5 m	9.2 m	7 m	est. 200 m
stand width	50 m	5.5 m	not measured	21.5 m	7 m	6.2 m	est. 100 m
culm density	10 / m^2	11 / m^2	not measured	61 / m^2	18 / m^2	8 / m^2	10 / m^2
culm height	216 cm	181 cm	not measured	173 cm	230 cm	185 cm	195 cm
culm diameter	3 cm	1.3 cm	not measured	3 cm	2.6 cm	2 cm	1.8 cm
stand type	NATIVE	NATIVE	NATIVE	INVASIVE	INVASIVE	NATIVE	NATIVE

Appendix

INSTRUCTIONS

CHECKLIST:

BEFORE YOU GO INTO THE FIELD PLEASE MAKE SURE TO TAKE THE FOLLOWING:

1. GPS unit or topographic map
2. Clippers to cut Phragmites stems
3. Zip-lock or plastic bags to store samples
4. Paper to record site information. Use printout of form from web
5. Pencil or pen (no ink please)
6. Camera

INSTRUCTIONS FOR FIELD COLLECTION:

1. Use the checklist to assemble the necessary tools and materials.
2. Once you arrive at the sampling location please take a picture of the stand (or several)
3. Fill out all pertinent information on the form sheet. Use data form provided on the web - http://invasiveplants.net/diagnostic/registration.asp
4. Record GPS (Lat/Long) coordinates.
5. Walk to the stand and cut 5 stems from last years growing season. Cut stems at base of shoot as far down as possible. Fold each stem individually and place into plastic bag. During the growing season when green stems from the current year are available, please also cut 5 green stems. Follow procedures as outlined above for older stems. Please place green stems into a separate plastic bag. If you continue to another sampling location, please make sure your samples are clearly marked with site name, GPS location etc. Ideally a piece of paper with this information should be kept in each plastic bag secured to the stems.
6. Once you return from the field, please enter all information via our website. Each sampling location will receive a unique reference number assigned by our website. You will receive this reference number once you submit and approve the information you entered. Please make a printout of this information for your own records and place a copy into the plastic bag with the old stems and another copy into the bag with the green stems. We will receive many samples and this system allows us to keep track of the samples and reduce mix-ups.
7. During the growing season when green stems are shipped, please send material ASAP after field collection. Please avoid sending samples that are wet since they will get moldy quickly. Otherwise, samples will last in plastic bags for a few days. Ideally they should arrive in Ithaca within 2-3 days after collection. This is less urgent for samples collected during the dormant season but avoid moist samples as well.
8. Place clearly labeled samples into shipment box or envelope and mail to:

Bernd Blossey
Department of Natural Resources
Fernow Hall, Cornell University
Ithaca, NY 14853